Elliptic flow measurement in Xe-Xe collisions at $\sqrt{S_{NN}}$ = 5.44 Tev

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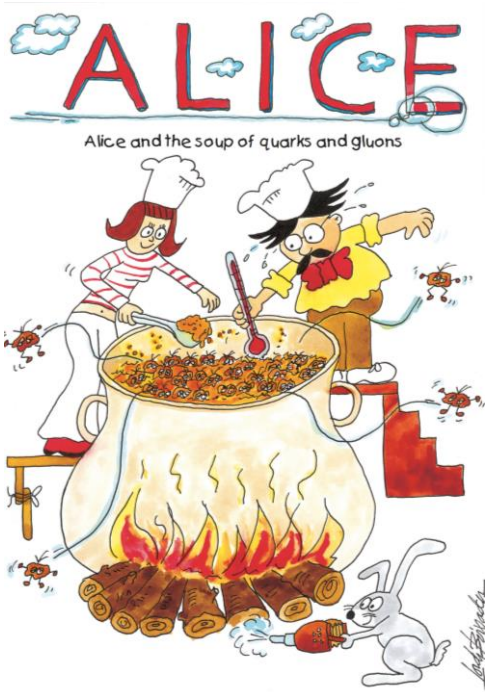
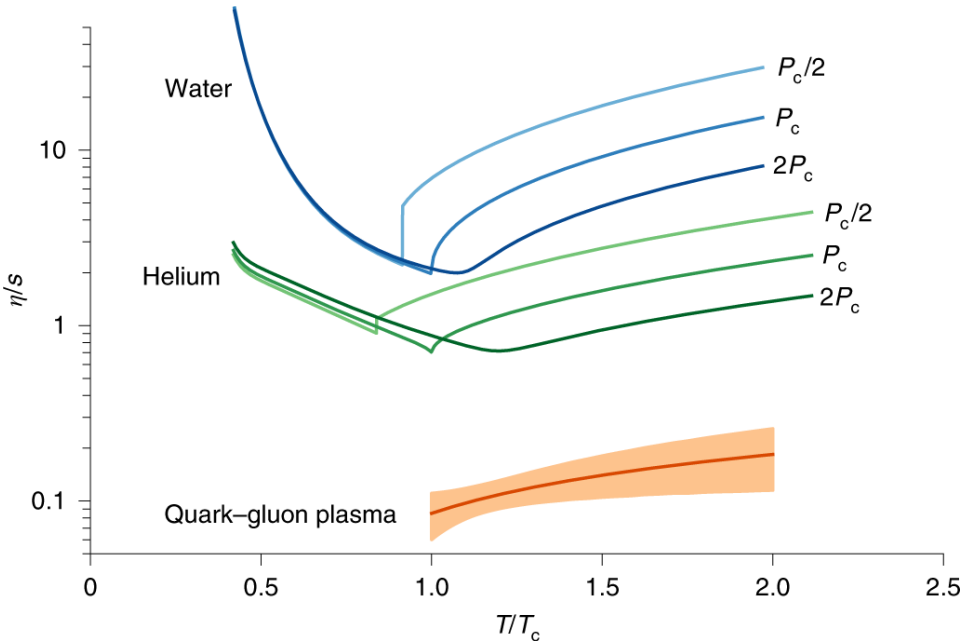
The 4th state of matter QGP: Quark Gluon Plasma



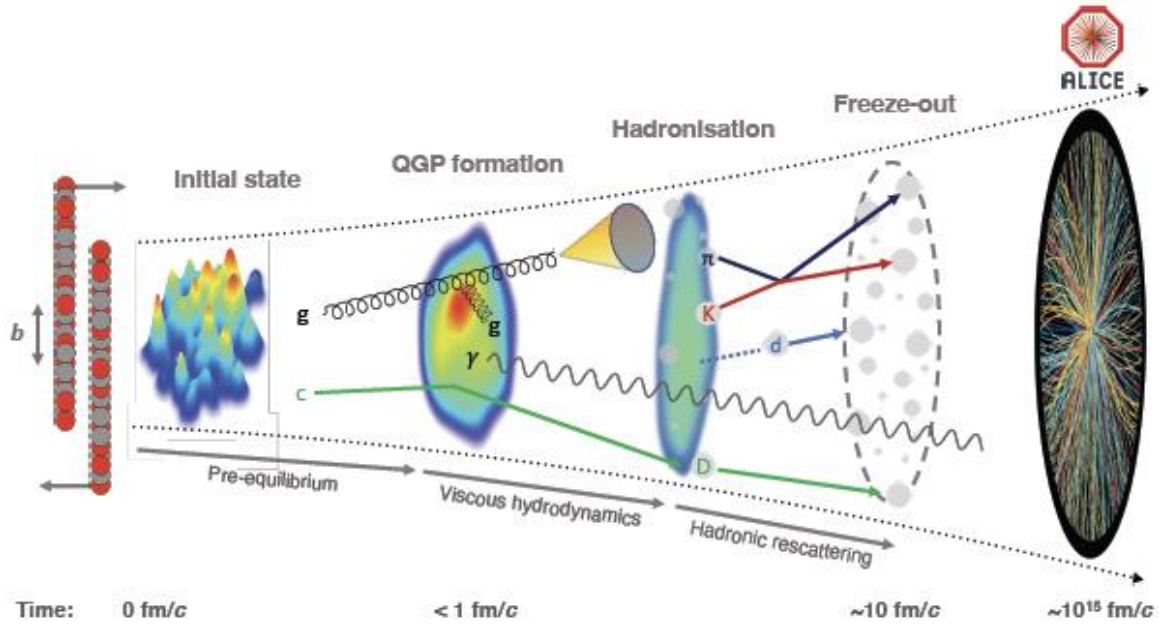
- Is a 'Soup' made of melted hadrons
  - Baryons(p, n)
  - Mesons (π, K)
- Colliding particles under high temperature + pressure = QGP
- It is a strongly coupled (almost perfect) liquid
- Heisenberg limit for η/s=0.08 (lowest viscosity in nature)

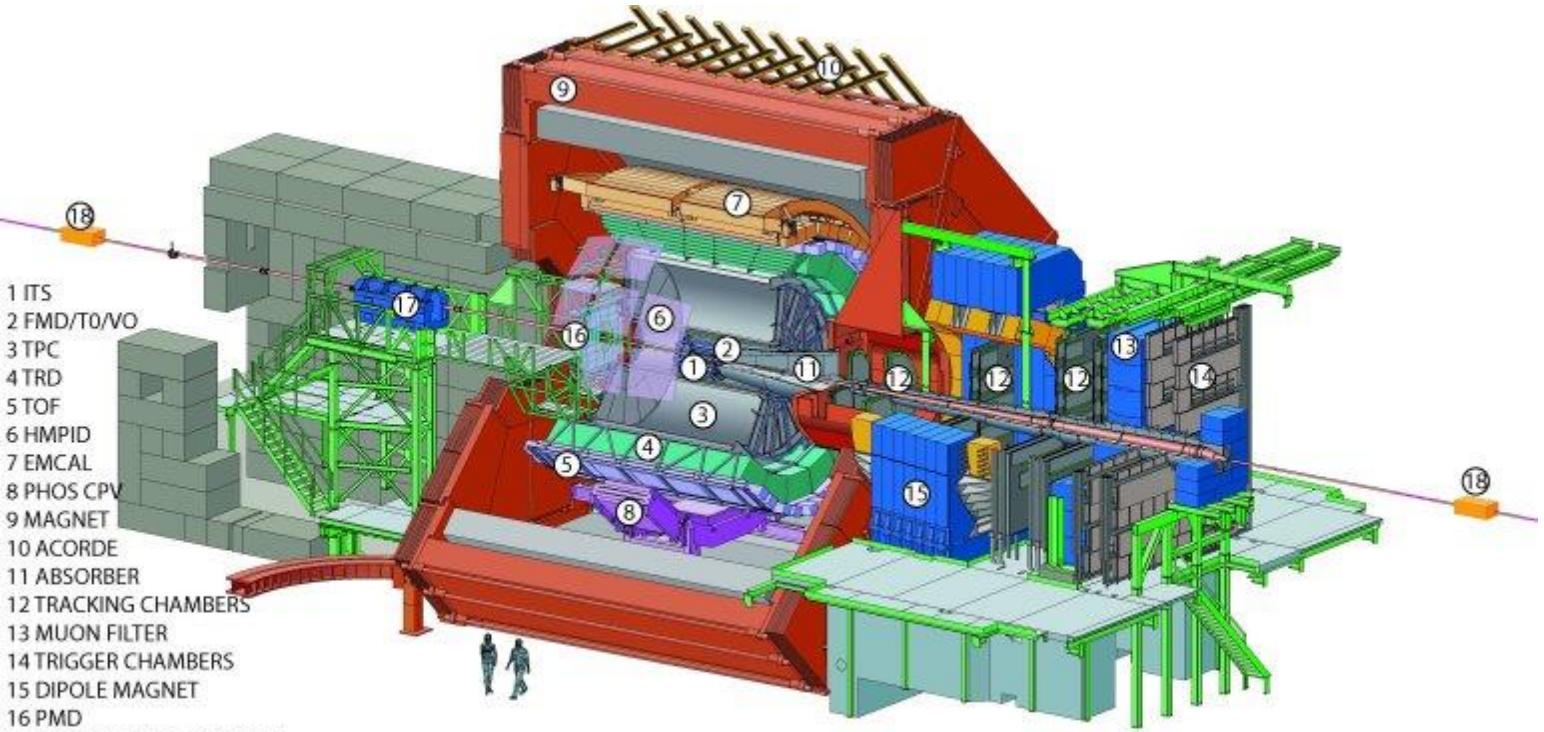


Goal of this analysis

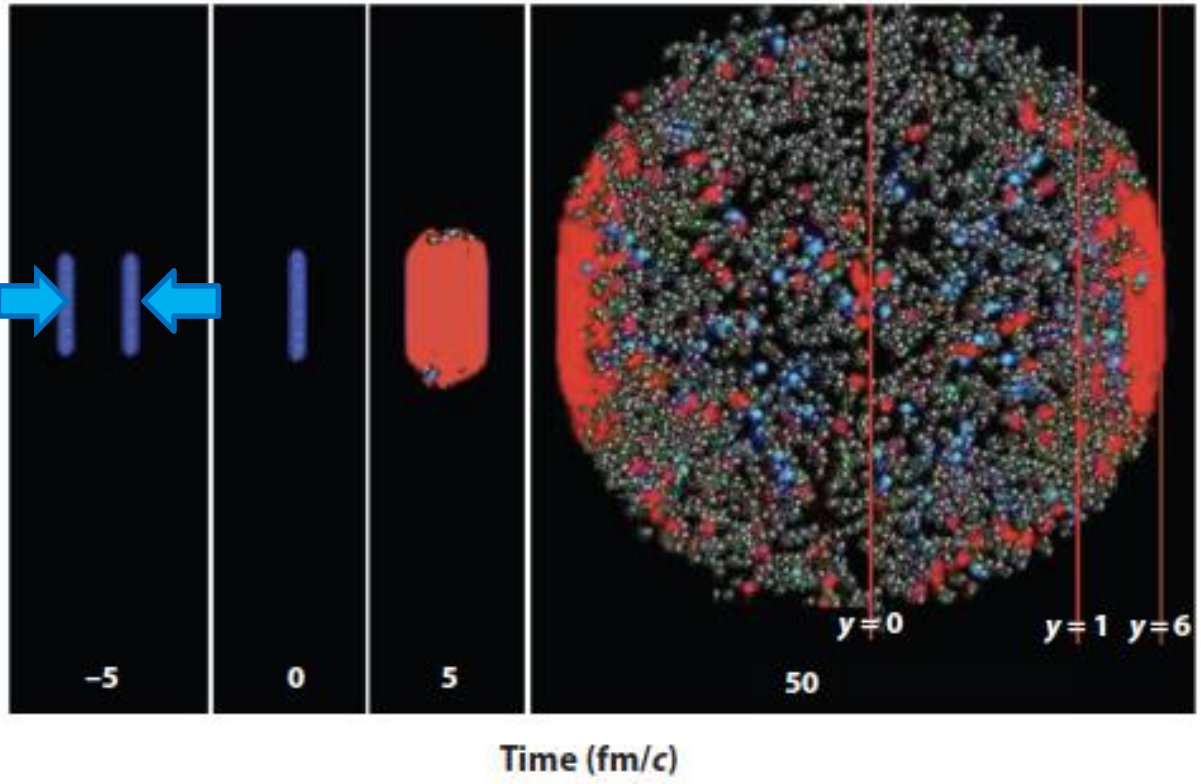
❖ Measure the elliptic flow with parameterization of the viscosity to entropy ratio

ALICE Detector





Anisotropic Flow



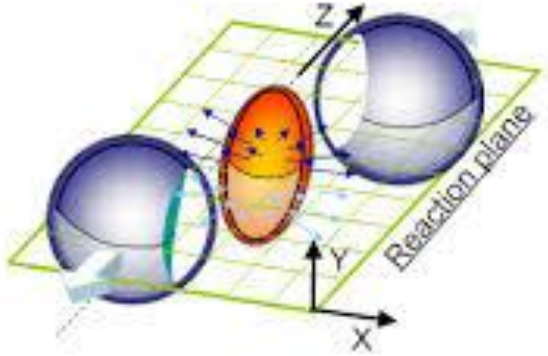
❑ Central collision = isotropic radial expansion.

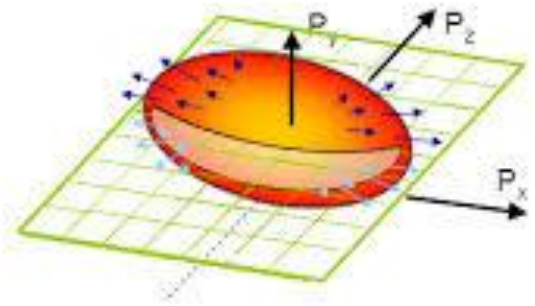
❑ As the system evolves and cools down at 50 fm/c :

- Blue/Grey spheres → Hadrons
- Red--> QGP

(x,y) → determine the eccentricity
(p_x, p_y) → determine the viscosity

❑ Non-central collision = Almond shape (geometrical anisotropy)





Interactions among constituents generate a pressure gradient.

The initial special anisotropy transforms into a momentum space anisotropy.

Q-cumulant method

- Particle's distribution equation in angular space : $\frac{dN}{d\varphi} \sim 1 + 2\,V_2\,\mathrm{Cos}2(\varphi - \psi)$
  - V_2 is the second order coefficient of the Fourier expansion.
  - Ψ (reaction plane angle) is not known → Use azimuthal correlations between particles.

- The Q-vector is defined as: $Q = \sum_{i}^{M} e^{in\varphi}$ (sum of cos and sin)

- For 2 particle correlation: $\boxed{< 2 >} = \frac{|Q_2|^2 - M}{M(M-1)}$ $\quad C_2\{2\} = \ll 2 \gg \quad V_2\{2\} = \sqrt{c_2\{2\}}$

Calculates the mean angle between two particles

- Multi-particle $V_2\{2\}$, $V_2\{4\}$, $V_2\{6\}$, $V_2\{8\}$ calculations are more complicated.
  - More particles correlations helps to obtain a clean signal.

Data analysis and cuts

- The data set was taken in 2017 and has a total of 4 million reconstructed collisions.
  - Data are minimum bias triggered (all collision).

    The trigger system decides when an interesting collision (event) should be recorded.

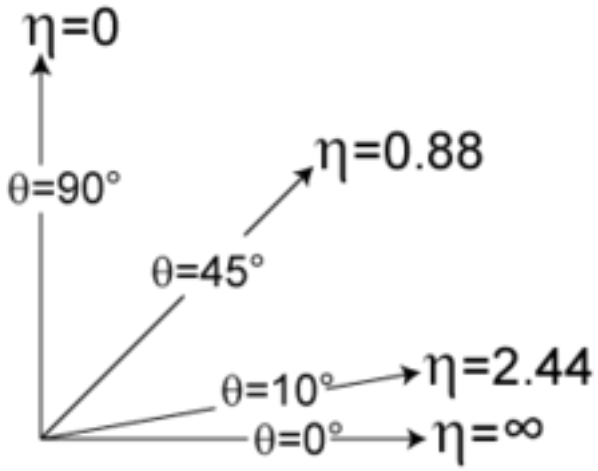
Event cuts

AliEventCuts class
(default setting)

Track cuts

$|\eta| < 0.8$ Pseudorapidity

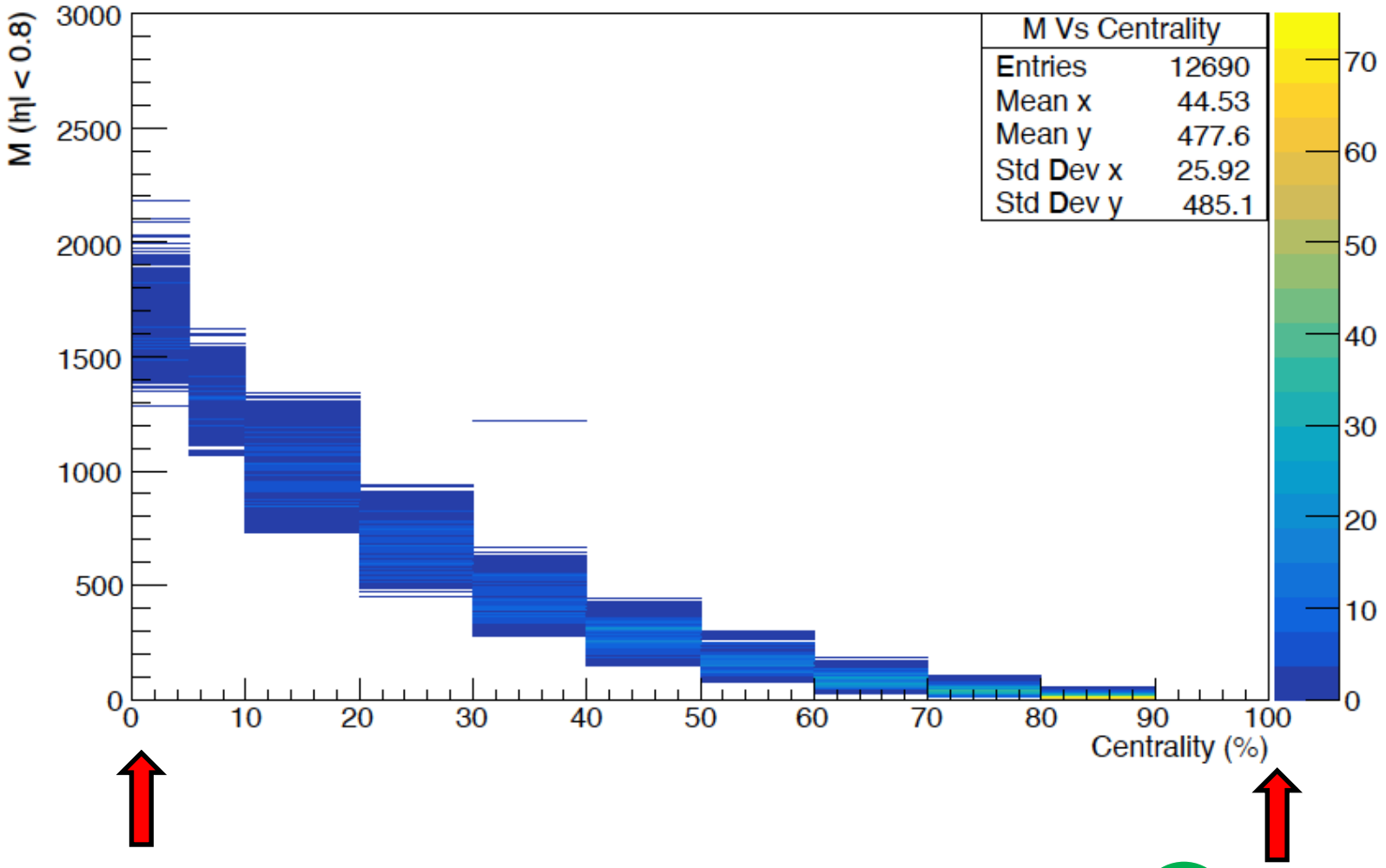
$0.2 < p_t < 3.0$ GeV/c Transverse momentum

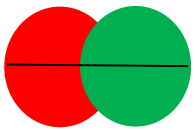


$$\eta = -\log[\tan\left(\frac{\theta}{2}\right)]$$

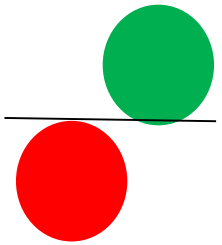
$$p_t = \sqrt{p_x{}^2 + py^2}$$

Multiplicity dependence



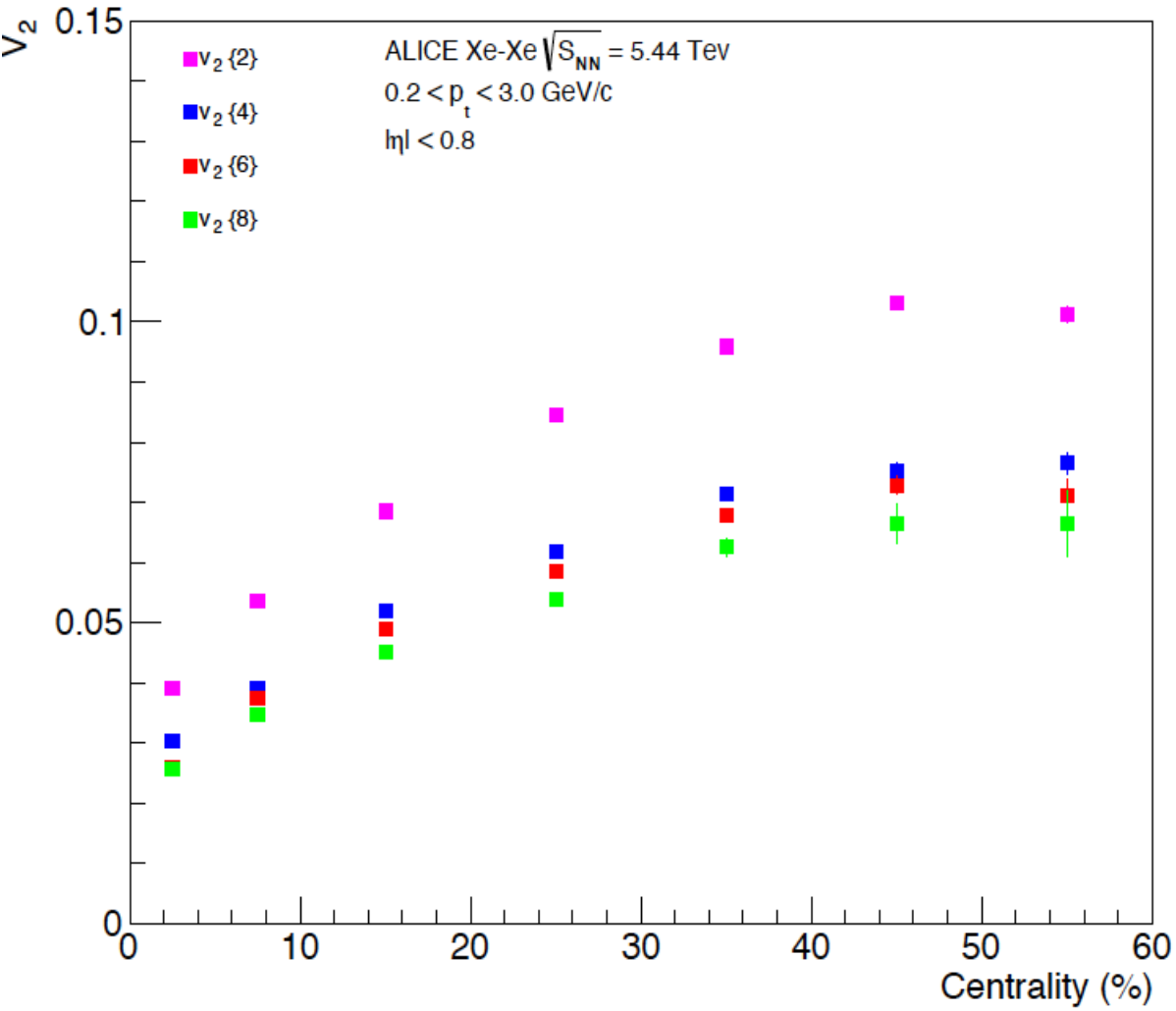


Ultra central



Ultra peripheral

Centrality Dependence of V_2



- The V_2 gets increased as we go to mid-peripheral collisions.
- By correlating more particles, we can separate flow from non-flow effects.
- The region between the $V_2\{2\}$ and $V_2\{4\}$, $V_2\{6\}$, $V_2\{8\}$ is the non - flow effects.
- By inserting a pseudorapidity gap $|\Delta\eta|$ on the $V_2\{2\}$ will lie exactly above the $V_2\{4\}$. Thus, we could suppress the non-flow effects.

Conclusions-Future Work

✓ Q-method calculate the flow directly from the data
✓ The V_2 flow is driven by the initial geometry of the system
✓ Multiparticle correlations give a clean probe of flow

➢ Investigate if the non-flow effects are suppressed by inserting a pseudorapidity gap

➢ Check with efficiency corrections for statistical and systematic errors

➢ Apply the analysis on Pb-Pb data.

^{54}Xe ^{82}Pb ○ Pb is almost double in size → different V_2 flow (higher than Xe-Xe).

Related Papers

- Annu. Rev. Nucl. Part. Sci. 2013.63:123-15 Collective Flow and Viscosity in Relativistic Heavy-Ion Collisions
- Annu. Rev. Nucl. Part. Sci. 2018.68:339-376 Heavy Ion Collisions: The Big Picture and the Big Questions
- arXiv:1805.01832v2 [nucl-ex] Anisotropic flow in Xe–Xe collisions at √sNN = 5.44 TeV
- S. A. Voloshin, A. M. Poskanzer, and R. Snellings, “Collective phenomena in non-central nuclear collisions,” Landolt-Bornstein 23 (2010) 293–333, arXiv:0809.2949 [nucl-ex].
- arXiv:2302.01238v1 [nucl-ex] ALICE upgrades during the LHC Long Shutdown 2
- arXiv:2211.04384v1 [nucl-ex] The ALICE experiment: A journey through QCD

Thank you!